NASA STTR 2009 Phase I Solicitation

T1 Information Technologies for System Health Management and the Study of Space Radiation Environments and Associated Health Risks

This topic seeks advances in the design, development, and operation of complex aerospace systems to enable safe operation in the event of system failures, innovative technologies for robotic exploration of planetary surfaces, and emerging technologies that will enable the optimization of limited resources and management of sustainable systems for space operations and Earth-based development.

Subtopics

T1.01 Information Technologies for System Health Management and Sustainability

Lead Center: ARC

Information technology is a key element in the successful achievement of NASA's strategic goals. Modern tools and techniques have the capability to redefine many design and operational processes as well as enable grand exploration and science investigations. This subtopic seeks innovative solutions to the following information technology challenges:

- Enabling technologies for sustainable systems such as life-cycle cost analysis, including production impact of system maintenance and upgrades, testing methodologies to maximize the efficiency of energy systems, optimization of limited resources, and smart energy systems that self-monitor and adjust accordingly to changing conditions;

- Health management systems that perform quickly enough to monitor a flight control system in a highly dynamic environment and respond to anomalies with suggested recovery or mitigation actions;

- Data fusion, data mining, and automated reasoning technologies that can improve sustainability, increase identification of system degradation, and enhance scientific understanding;

- Techniques for analyzing and reasoning from development and operational data sets to identify degradation of components and predict remaining useful life;

- Techniques for interconnecting and understanding large heterogeneous or multidimensional data sets or data with complex spatial and/or temporal dynamics;

- Computational and human/computer interface methodologies for inferring causation from associations and background knowledge for scientific, engineering, control, and performance analyses.

T1.02 Information Technologies for Intelligent Planetary Robotics

Lead Center: ARC

The objective of this subtopic is to develop information technologies that enable planetary robots to better support human exploration. Since February 2004, NASA has been actively engaged in a long-term program to explore the

solar system and beyond, beginning with robotic missions to the Moon and leading eventually to human exploration of Mars. Several NASA studies have concluded that extensive and pervasive use of intelligent robots can significantly enhance human exploration, particularly for surface missions that are progressively longer, more complex, and must operate with fewer ground control resources.

Robots can do a variety of work to increase the productivity of human explorers on the Moon or Mars. Robots can perform tasks that are tedious, highly-repetitive or long-duration. Robots can perform tasks that help prepare (or help optimize planning) for future crew activity. Robots can perform "follow-up" work, completing tasks started by humans. Example tasks include: robotic recon (advance scouting), systematic site surveys, documenting sites or samples, and unskilled labor (initial site prep, site clean-up, etc).

Proposals are sought which address the following technology needs:

- Intelligent subsystems (algorithms, software and hardware) to improve the mobility or manipulation performance of planetary rovers. Mobility subsystems, such as traction control or active suspension, that enable MER- to MSL- scale rovers to drive at 3 m/s over lunar-relevant terrain while carrying a 100 kg payload are of particular interest. Manipulation subsystems, such as modular end-effectors for deploying instruments or placing markers, are also sought.

- Ground control user interfaces and data management systems for robotic exploration. Proposals should focus on software tools for planning variable-duration and variable-complexity command sequences; for event summarization and notification; for interactively monitoring/replaying task execution; for managing geospatial information; and for automating ground control functions.

- Autonomous surface navigation (localization and hazard avoidance) over long-distances and in permanently shadowed regions. Novel "infrastructure free" techniques that utilize passive computer vision (real-time dense stereo, optical flow, etc.), active illumination (e.g., line striping), repurposed flight vehicle sensors (low light imager, star trackers, etc.), and wide-area simultaneous localization and mapping (SLAM) are of particular interest.

- Physics-based simulation to develop and test planetary rover algorithms and systems. Existing mobile

robot simulators (e.g., Player-Stage) lack the fidelity required to test high (and varying) levels of rover autonomy in non-terrestrial environments. Proposals are sought that provide robot simulation frameworks with models for planetary illumination, surface composition, specialized sensor and scientific instruments, communication, and rover resources.

- Robot software architecture that radically reduces ground control requirements for remote operations of planetary rovers. This may include: on-board health management and prognostics, on-board automated data triage (to prioritize information for downlink to ground), and learning algorithms to improve hazard detection and manage locomotion control modes switching.